IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE HONORABLE
BOARD OF PATENT APPEALS AND INTERFERENCES

IN RE PATENT APPLICATION OF:	**CHEN** ***et al.***
SERIAL NO.:	**10/670,795**
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FOR:	TOKYO ELECTRON LIMITED

- APPEAL BRIEF UNDER 37 C.F.R. §41.37 -

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Date: May 22, 2006

Mail Stop APPEAL BRIEF - PATENTS
Commissioner for Patents
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Dear Sir:

Further to the Notice of Appeal, filed on December 22, 2005, Appellants respectfully submit this Appeal Brief pursuant to 37 C.F.R. §41.37 along with a three (3) month extension of time.

The Director is authorized to charge the $500.00 fee for filing an Appeal Brief pursuant to 37 C.F.R. §41.20(b)(2) as well as the $1020.00 fee for the extension of time pursuant to 37 C.F.R. 1.17(a)(3). The Director is further authorized to charge any additional fees that may be due, or credit any overpayment of same to Deposit Account No. **033975** (Ref. No. 071469-0306049).

- REQUIREMENTS OF 37 C.F.R. § 41.37 -

I. 37 C.F.R. § 41.37(c)(1)(i) – REAL PARTY IN INTEREST

The real party in interest for this Appeal and the present application is TOKYO ELECTRON LIMITED by way of an Assignment recorded in the U.S. Patent Trademark Office at Reel/Frame: 014866/0467.

II. 37 C.F.R. § 41.37(c)(1)(ii) - RELATED APPEALS AND INTERFERENCES

There are presently no appeals or interferences known to the Appellants, the Appellants' representatives or the Assignee, which will directly affect or be directly affected by or have a bearing on the Board's decision in the pending appeal.

III. 37 C.F.R. § 41.37(c)(1)(iii) - STATUS OF CLAIMS

Pending: Claims 1-146 are pending.

Withdrawn: Claims 1-92 and 120-143 have been withdrawn.

Rejected: Claims 93-119 stand rejected.

Cancelled: No claims have been cancelled.

Allowed: No claims have been allowed.

On Appeal: The rejections of claims 93-119 are appealed as well as dependent claims 144-146, introduced in the Amendment of April 27, 2005, but not acknowledged by the Examiner in the Final Office Action of July 27, 2005.

Of the claims on appeal, claim 93 is the sole independent claim as claims 94-119 and claims 144-146 depend either directly or indirectly from claim 93. The claims on appeal are set forth in the attached Appendix.

IV. 37 C.F.R. § 41.37(c)(1)(iv) - STATUS OF AMENDMENTS

No amendments have been filed subsequent to the Final Office Action of July 27, 2005.

V. 37 C.F.R. § 41.37(c)(1)(v) - SUMMARY OF CLAIMED SUBJECT MATTER

Independent claim 93, as described below, includes references and citations to the specification, drawings, and reference numerals. Such description is intended to facilitate an understanding of the claims by the Board members and is not intended as a comprehensive claim construction, such as used in the context of an argument of invalidity or infringement. Any reference to more than one reference number or character for any particular claimed element or limitation is illustrative only and is not to be construed as an admission that the claims are limited to any, or all, of the particularly disclosed embodiments.

The claimed subject matter relates to a method of removing a layer of high-permittivity (high-k) dielectric material during, for example, a stage of the manufacture of an integrated circuit. In the embodiments of interest, a first process gas is used to modify a high-k dielectric layer by exposing the layer to a plasma treatment. The plasma species have sufficient energy to effectively disrupt and/or reduce the thickness of the high-k layer through interaction with the layer. Following the plasma treatment, the modified part (and possibly also the unmodified part) of the high-k layer is etched by a non-plasma process utilizing a second process gas comprising etch reactants that form volatile etch products when exposed to the modified high-k layer. (*See*, Specification: par. **[0090]**, **[0091]**). The plasma treatment process parameters may comprise substrate temperature, process pressure, choice of process gases and relative gas flows of the process gases. Exemplary parameters may, for example, include a chamber pressure less than 10 Torr, a process gas flow rate less than 2000 sccm, an etch reactant gas flow rate less than 1000 sccm (including a carrier gas), and a substrate temperature less than 400°C. (*See*, Specification: par. **[0104]**).

To this end, claim 93 specifically sets forth the following:

> A method for processing (FIG. 16: par. **[0034]**, **[0090]**, **[0091]**, **[0100]**) a layer containing a high-permittivity material (par. **[0003]**-**[0004]**), the method comprising:
>
> modifying a layer containing a high-permittivity material by exposing the layer to a first process gas in a plasma (FIG. 16: ref. num. **1604** par. **[0100]**, **[0105]**- **[0109]**); and
>
> etching the modified high-permittivity layer in the absence of a plasma by exposing the layer to a second process gas comprising an etch reactant (FIG. 16: ref. num. **1610** par. **[0101]**).

VI. 37 C.F.R. § 41.37(c)(1)(vi) - GROUNDS OF REJECTION TO BE REVIEWED

The Final Office Action rejected claims 93-119, under 35 U.S.C. §102(e), as allegedly being anticipated by U.S. Patent No. 6,666,986 to Vaarstra *et al.* (hereinafter "Vaarstra '986") and rejected claim 105, under 35 U.S.C. §103(a), as allegedly being unpatentable over Vaarstra '986 in view of U.S. Patent No. 6,613,695 to Pomerade *et al.* (hereinafter "Pomerade '695"). (*See,* Final Office Action, pp. 2-7). The Examiner did not acknowledge dependent claims 144-146, which were filed in the Amendment of April 27, 2005, prior to the issuance of the Final Office Action.

VII. 37 C.F.R. § 41.37(c)(1)(vi) - ARGUMENT

To the point, the prior art rejections made by the Examiner fail because neither Vaarstra '986 nor Pomerade '695 teach or suggest the claimed combination of elements requiring modifying a high-permittivity layer by exposing it to a first process gas in a plasma and then etching the modified high-permittivity layer, in the absence of a plasma, by exposing the layer to a second process gas comprising an etch reactant. At best, Vaarstra '986 discloses the generation of supercritical fluids by subjecting certain gases to

tremendous pressures (and sometimes temperatures) then exposing substrate material to the supercritical fluid to remove a portion of the material. Not only do the disclosed methods lack any reference to plasma treatments, in contravention of the language of claim 93, they also effectively teach away from such a feature.

Pomerade '695 is equally deficient as it merely teaches the cleaning of certain surfaces with plasma products prior to depositing silicon layers. In so doing, there is nothing that suggests etching the modified high-permittivity layer, in the absence of a plasma, by exposing the layer to a second process gas comprising an etch reactant, as required by claim 93. Furthermore, Pomerade '695 cannot be reasonably combined with Vaarstra '986 as their respective teachings are incompatible with each other.

A. Claims 93-119 & 144-146 Are Not Anticipated by Vaarstra '986

The Examiner argued that Vaarstra '986 anticipates claims 93-119, under 35 U.S.C. § 102(e). The rejection is woefully unsupported.

Anticipation requires that a single prior art reference disclose, either expressly or inherently, each and every element of the claimed invention. *See Verdegaal Bros. v. Union Oil Co. of California* , 814 F.2d 628, 631, 2 USPQ2d 1051, 1053 (Fed. Cir. 1987); *Hybritech Inc. v. Monoclonal Antibodies, Inc.*, 802 F.2d 1367, 1379, 231USPQ2d 81, 90 (Fed. Cir. 1986). The prior art reference must describe the claimed subject matter "sufficiently to have placed a person of ordinary skill in the field of the invention in possession of it." *In re Spada*, 911 F.2d 705, 708, 15 USPQ2d 1655, 1657 (Fed. Cir. 1990).

Sole independent claim 93 explicitly requires modifying a layer containing a high-permittivity material by ***exposing the layer to a first process gas in a plasma***. In stark contrast, there is nothing in Vaarstra '986 that expressly or inherently teaches such a feature. Specifically, Vaarstra '986 discloses a method for etching an inorganic material of

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a substrate includes providing a semiconductor-based substrate having an exposed inorganic material and exposing the substrate to a supercritical etching composition to remove at least a portion of the inorganic material from the substrate. (*See*, Vaarstra '986: col. 3, lines 18-22). Vaarstra '986 provides that supercritical compositions or "fluids" are subjected to tremendous pressures (and sometimes temperatures) to achieve high solvating capabilities akin to liquids while maintaining low, gas-like viscosities. (*See*, Vaarstra '986: col. 3, lines 18-22; *see also* Example 1: *supercritical* HF: 188°C, 6.58 MPa (49,354 Torr) at col. 9, lines 46-50; Example 2: *supercritical* CO_2: 60°C, 10.13 MPa (76,000 Torr) at col. 9, lines 60-64); Example 3: *supercritical* H_2O: 375°C, 22.29 MPa (167,200 Torr) at col. 10, lines 9-14).

Vaarstra '986 further discloses, in exacting detail, the configuration of two pressure vessels for effecting its supercritical etching method. (*See*, Vaarstra '986: FIGs. 1,2). FIG. 1 depicts the (first) pressure vessel **14** having a mixing manifold **22**, in which components can be brought to the supercritical state by including heating coils or vanes in the manifold **22** walls to increase heat transfer to the components before passing through an optional circulation heater **24**. The supercritical etching composition enters the pressure vessel **14** through a dispensing device **26**, such as a shower-head. The circulation heater **24** is preferably used to increase the efficiency of the system when creating the supercritical etching composition in the mixing manifold **22** prior to entering the pressure vessel **14**. The supercritical etching composition passes over the substrate **16** from the dispensing device **26**. (*See*, Vaarstra '986: col. 7, lines 19-34; FIG. 1).

Temperature and pressure within the pressure vessel **14** is maintained at or above the critical temperature and pressure for the supercritical component. The etching component is then dissolved in the supercritical composition as a non-supercritical component or is itself in the supercritical state as part of the supercritical component, depending on the temperature and pressure within the pressure vessel **14**. A thermocouple **28** monitors temperature within the pressure vessel **14** and relays an appropriate signal to a

temperature control unit **30**. The temperature control unit **30** sends appropriate signals to heater inputs **32**, which provide heat to the pressure vessel **14**. A pressure gauge **34** monitors pressure within the pressure vessel **14** and sends appropriate signals to a pressure control unit **36**, which pressurizes/depressurizes the pressure vessel **14**. Excess composition is vented or pumped through a vent or pumping system in the direction indicated by arrow **38**. The supercritical etching composition passes from the pressure vessel **14** to the vent or pumping system **38** by operation of a pressure differential between adjacent chambers. The pressure in the vent or pumping system **38** is lower than the pressure within the pressure vessel **14** causing this transfer. (*See*, Vaarstra '986: col. 7, lines 44-65; FIG. 1).

Vaarstra '986 alternately discloses a (second) pressure vessel, which is similar to the (first) pressure vessel **14**, except that the supercritical component first flows from mass or liquid flow controller **40** through circulation heater **24** prior to entering the mixing manifold **22**, where any non-supercritical components enter through mass or liquid flow controllers **42**. (*See*, Vaarstra '986: col. 8, lines 2-13; FIG. 2).

Despite these comprehensive and detailed disclosures, there is nothing that teaches or suggests the use of plasma in the disclosed supercritical etching method – much less, teaching exposing the substrate to a first process gas in a plasma, as required by claim 93. Vaarstra '986 uses the term "plasma" only once, in the background section, to distinguish between wet etching and dry etching techniques. However, as it is clear to one of ordinary skill in the art, plasma is not the only dry etching technique available. Rather there exists other non-plasma dry etching techniques, such as, for example, XeF_2 etching and interhalogen etching.

If anything, Appellants submit that the disclosures of Vaarstra '986 serve to teach away from the use of plasma. For example, consider the pressure vessels disclosed by Vaarstra '986. Despite their highly-detailed configurations, there is nothing to suggest that

the pressure vessels are capable of generating or sustaining plasma products. That is, there is absolutely no mention of plasma-related components incorporated in the pressure vessels, such as, for example, the use of electrodes, radio frequency power, radio frequency generators, impedance matching networks, *etc.*, to support plasma.

Equally notable, is the tremendous pressures at which the disclosed supercritical etching method works. Appellants submit that artisans of ordinary skill will readily appreciate that such pressures are not consistent, in any way, with plasma treatments. Typical plasma treatments operate under pressures of 10 Torr or less – not the tens of thousands to hundreds of thousands of Torr required by the disclosed supercritical etching method. In fact, the secondary reference Pomerade '695, which does teach the use plasma – but, as will be discussed below, fails on other grounds – clearly states that the plasma reaction chamber pressure must be kept below 10 Torr to maintain operations. (*See*, Pomerade '695: col. 13, lines 50-53).

For at least these reasons, Appellants, therefore, respectfully submit that Vaarstra '986 cannot be reasonably construed to anticipate independent claim 93. Because dependent claims 94-119 and 144-146 depend, either directly or indirectly from claim 93, claims 94-119 and 144-146 are also not anticipated by Vaarstra '986 by virtue of dependency as well as for their additional recitations.

B. Claims 93-119 & 144-146 Are Not Obvious Over Vaarstra '986 & Pomerade '695

The Examiner argued that Vaarstra '986 fails to teach that hafnium oxide is a high dielectric constant material and therefore relied on Pomerade '695 to render claim 105 unpatentable, under 35 U.S.C. § 103(a). Appellants strenuously disagree.

In rejecting claims under 35 U.S.C. § 103(a), several basis factual inquiries must be made to determine obviousness or non-obviousness of patent application claims under 35 U.S.C. § 103. These factual inquiries are set forth in *Graham v. John Deere Co.*, 383 US 1, 17, 148 USPQ 459, 467 (1966):

> Under §103, the scope and content of the prior art are to be determined; differences between the prior art and the claims at issue are to be ascertained; and the level of ordinary skill in the pertinent art resolved. Against this background, the obviousness or non-obviousness of the subject matter is determined.

As stated by the Federal Court in *In re Ochiai*, 37 USPQ 2d 1127, 1131 (Fed. Cir. 1995):

> [T]he test of obviousness *vel non* is statutory. It requires that one compare the claim's subject matter as a whole with the prior art to which the subject matter pertains. 35 U.S.C. § 103. The inquiry is thus ***highly fact-specific by design*** . . . When the references cited by the Examiner fail to establish a *prima facie* case of obviousness, the rejection is improper and will be overturned. *In re Fine*, 837 F.2d 1071, 1074, 5 USPQ2d 1596, 1598 (Fed. Cir. 1988) (*Emphasis added.*)

In rejecting claims under 35 U.S.C. § 103(a), an Examiner bears an initial burden of presenting a *prima facie* case of obviousness. A *prima facie* case of obviousness is established only if there is a suggestion or motivation to combine reference teachings; a reasonable expectation of success; and the prior art references, when combined, teach or suggest all the claim limitations. If an Examiner fails to establish a *prima facie* case, a rejection is improper and will be overturned. (*See*, *In re Rijckaert*, 9 F.3d 1531, 28 USPQ2d 1955 (Fed. Cir. 1993). "If examination . . . does not produce a *prima facie* case of unpatentability, then without more, the Applicant is entitled to the grant of the patent." (*In re Oetiker*, 977 F.2d 1443, 1445-1446, 24 USPQ2d 1443, 1444 (Fed. Cir. 1992)).

Appellants first submit that Pomerade '695 cannot be used with Vaarstra '986 to render any of the claims unpatentable, including rejected claim 105. This is because Pomerade '695 cannot, in any way, be reasonably combined with Vaarstra '986 as the respective methods and systems are clearly incompatible. Pomerade '695 is directed to the use of ***plasma products*** to treat or clean the substrate surfaces. (*See*, Pomerade '695: col. 3, lines 32-33). In contrast, as discussed above, Vaarstra '986 is directed to the use of supercritical fluids and supercritical non-plasma etching techniques.

Moreover, as also noted above, Pomerade '695 admonishes that, to maintain operations, the pressure within the plasma reaction chamber must be kept below 10 Torr. (*See*, Pomerade '695: col. 13, lines 50-53). On the other hand, Vaarstra '986 teaches the use of tens of thousands to hundreds of thousands of Torr to achieve supercritical etching. As such, it is an unreasonable leap of faith to assert that it would either be obvious to combine the two references or that there exists motivation to do so, given the disparate teachings of both references.

With this said, Appellants further submit that even if, *in arguendo*, Pomerade '695 were to be used with Vaarstra '986, their combined teachings (to the extent that such teachings could possibly exist), cannot defeat the patentability of independent claim 93.

Claim 93 not only requires the modification of the high-permittivity layer via plasma it also requires ***etching*** the modified high-permittivity layer ***in the absence of a plasma by exposing the layer to a second process gas comprising an etch reactant.*** In dramatic contrast, there is nothing in Pomerade '695 that expressly or inherently teaches such a feature. Specifically, Pomerade '695 discloses methods for treating or cleaning substrate surfaces with plasma products in preparation for subsequent deposition. (*See*, Pomerade '695: col. 3, lines 32-33). The substrate surfaces are first exposed to an excited species treatment **110**, which may include exposure to fluorine or chlorine radicals in sufficient supply to break surface bonds, but ***insufficient to etch the preferred silicon***

surface. Sources gases provided to the plasma generator **60** include NF_3, F_2, $B_2 F_6$, C_{l2}, CF_4, *etc*. and although inert gases may be used, the total flow rates and partial pressures are arranged to keep reaction chamber pressure below about 10 Torr for maintaining operation of the remote plasma unit. (*See*, Pomerade '695: col. 10, lines 28-38; FIG. 3).

Following excited species treatment **110**, the gate dielectric is deposited **120** over the treated surface. The deposition **120** may also include radical species flow; however, in such a case, the radical supply from the excited species treatment **110** will typically be different from the supply employed in the deposition **120**. Accordingly, the flow of radicals from the excited species treatment **110** is stopped prior to deposition **120**. (*See*, Pomerade '695: col. 11, lines 5-10; FIG. 3). Pomerade '695 further discloses the application of another round of excited species treatment **125** after the deposition **120** in which, once again, the treatment **125** is tuned such that the excited species ***does not etch*** the substrate or significant diffusion of active species into the bulk material of the gate dielectric. (*See*, Pomerade '695: col. 13, lines 14-23; FIG. 3).

Thus, Pomerade '695 clearly teaches the plasma-based, non-etch cleaning of a substrate surface prior to deposition of a gate dielectric. In so doing, Pomerade '695 neither teaches, suggests, nor otherwise contemplates the etching of the substrate surface – much less, exposing the surface, in the absence of plasma, to a second process gas comprising an etch reactant, as required by claim 93.

For at least these reasons, Appellants, therefore, respectfully submit that the combination of Vaarstra '986 and Pomerade '695 cannot render claim 93 unpatentable. And, because dependent claims 94-119 and 144-146 depend, either directly or indirectly from claim 93, claims 94-119 and 144-146 are also not rendered unpatentable by Vaarstra '986 and Pomerade '695 by virtue of dependency as well as for their additional recitations.

VIII. 37 C.F.R. §41.37(c)(1)(viii) - Claims Appendix

APPENDIX A: The pending claims (claims 1-146) are attached in **APPENDIX A.**

IX. 37 C.F.R. §41.37(c)(1)(ix) - Evidence Appendix

APPENDIX B: (NONE)

X. 37 C.F.R. §41.37(c)(1)(x) - Related Proceedings Index

APPENDIX C: (NONE)

XI. CONCLUSION

For at least the foregoing reasons, it is respectfully submitted that claims 93-119 and 144-146 are neither anticipated by Vaarstra '986, under 35 U.S.C. §102(e), nor obvious in view of Vaarstra '986 and Pomerade '695, under 35 U.S.C. §103(a).

Appellants, therefore, respectfully request this Honorable Board to reverse the rejection of these claims and direct that the claims be passed to issue.

Date: **May 22, 2006**

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- APPENDIX A -

93. (Original) A method of processing a layer containing a high-permittivity material, the method comprising:

modifying a layer containing a high-permittivity material by exposing the layer to a first process gas in a plasma; and

etching the modified high-permittivity layer in the absence of a plasma by exposing the layer to a second process gas comprising an etch reactant.

94. (Original) The method according to claim 93, wherein the layer containing a high-permittivity material overlies another layer in a substrate.

95. (Original) The method according to claim 94, further comprising providing the substrate in a process chamber.

96. (Original) The method as claimed in claim 93, wherein the modifying step partially removes the layer containing the high-permittivity material.

97. (Original) The method as claimed in claim 93, wherein the modifying step partially disassociates the layer containing the high-permittivity material.

98. (Original) The method according to claim 93, wherein the first process gas comprises a reactive gas.

99. (Original) The method according to claim 96, wherein the reactive gas comprises at least one of HBr and HCl.

100. (Original) The method according to claim 98, wherein the first process gas further comprises an inert gas.

101. (Original) The method according to claim 100, wherein the inert gas is selected from He, Ne, Ar, Kr, Xe, and N_2, or mixtures thereof.

102. (Original) The method according to claim 93, wherein the first process gas comprises an inert gas.

103. (Original) The method according to claim 102, wherein the inert gas comprises at least one of He, Ne, Ar, Kr, Xe, and N_2.

104. (Original) The method according to claim 93, wherein the high-permittivity material comprises at least one of Ta_2O_5, TiO_2, ZrO_2, Al_2O_3, HfSiO, and HfO_2.

105. (Original) The method according to claim 104, wherein the high-permittivity material comprises HfO_2.

106. (Original) The method according to claim 93, wherein the etch reactant comprises a β -diketone.

107. (Original) The method according to claim 106, wherein the β -diketone comprises at least one of acacH, tfacH, and hfacH.

108. (Original) The method according to claim 107, wherein the β -diketone comprises hfacH.

109. (Original) The method according to claim 93, wherein the second process gas further comprises an inert gas.

110. (Original) The method according to claim 109, wherein the inert gas comprises at least one of He, Ne, Ar, Kr, Xe, and N_2.

111. (Original) The method according to claim 93, wherein the second process gas further comprises an oxygen-containing gas.

112. (Original) The method according to claim 111, wherein the oxygen-containing gas comprises at least one of O_2, H_2O, and H_2O_2.

113. (Original) The method according to claim 95, further comprising modifying the substrate temperature at less than about 400° C.

114. (Original) The method according to claim 95, further comprising modifying the substrate temperature at less than about 200° C.

115. (Original) The method according to claim 93, wherein the modifying and the etching are carried out in the same process chamber.

116. (Original) The method according to claims 93, wherein the modifying and the etching are carried out in different process chambers.

117. (Original) The method according to claim 93, further comprising modifying a flow rate of the second process gas at less than 2000 sccm.

118. (Original) The method according to claim 106, further comprising modifying a flow rate of a β -diketone-containing carrier gas at less than 1000 sccm.

119. (Original) The method according to claim 93, further comprising modifying a flow rate of the etch reactant at less than 1000 sccm.

144. (New) The method according to claim 95, wherein the process chamber has a chamber pressure less than 10 Torr.

145. (New) The method according to claim 115, wherein the process chamber has a chamber pressure less than 10 Torr.

146. (New) The method according to claim 116, wherein at least one of the process chambers has a chamber pressure less than 10 Torr.

- APPENDIX B -

(NONE)

- APPENDIX C -

(NONE)